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ADVANCED SPECTRUM ANALYZER.(U)
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ADVANCED SPECTRUM ANALYZER

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ADVANCED SPECTRUM ANALYZER OPTICAL SYSTEM DESIGN

1.0 INTRODUCTION

During the fourth bimonthly report period the bulk of the effort was once again placed on characterizing lasers which might be used as sources on the spectrum analyzer and in attempting to butt-couple lasers to our devices. We also attempted for the first time to fabricate some geodesic lenses on a different diamond-turning facility located at Pneumo-Precision, Inc. in Keene, New Hampshire, and performed additional systems analyses in an effort to better characterize the spectrum analyzer performance when operating on very short pulses of RF power.

We will report the progress in each of these areas in the subsequent sections of this report together with a discussion of our plans for the next bimonthly report period and a financial statement regarding the program expenditures to this point in the effort.

2.0 LASER BUTT-COUPLING

The second and third bimonthly reports discuss the successful butt-coupling of a General Optronics laser to one of our waveguides. This type of effort was continued during this period using General Optronics' laser diode No. WH-5, the most useful of the four most recently delivered devices. The height of the emitting region above the heat sink was again determined by means of Lloyd's fringes, but the accuracy of this procedure was reduced significantly because the specular surface of the diamond-turned heat sink had been degraded by etching before the diode was mounted. The butt-coupling fixture was mounted onto a spectrum analyzer substrate and the laser-waveguide separation was set at 1 to 3 μm. Attempts to observe waveguided radiation at the output edge of the substrate were unsuccessful despite in-place adjustment of the diode height. Eventually the mount was removed from the IO substrate in order that the height measurement could be repeated, and it was found that the front facet of the laser had been damaged and the diode no longer lased.

Of the other three General Optronics diodes (#'s WH-3, 4, and 6) one was found on initial test to be only an LED, one was on a heat sink so severely degraded that the height could not be measured, and one had excessive beam divergence.

In addition to the work with General Optronics lasers we were also given two lasers by RCA. These devices were mounted on their heat sinks with the front facet in very close proximity to the front face of the heat sink. The fact that these devices were premounted on the RCA heat sink presented major problems in attempting to butt-couple these lasers using our coupling fixture. We did modify one of our copper heat sinks by milling a rectangular groove through it so that it would provide a very tight pressure fit to the RCA heat sink. This latter device was then tapped into position and the height of the active region was determined using a filar eyepiece on a microscope. The remainder of the butt-coupling procedure was then performed exactly as if the laser was mounted on our heat sink. While we were given two such lasers by RCA we were successful in performing this procedure on only one of these. The other laser was found to have been rotated at an angle of the order of 13° with respect to the front face of the RCA heat sink. This would present a very difficult alignment if we were to attempt to mount this particular device into one of our heat sinks.

The RCA lasers are significantly better than either the Gneral Optronics, the Hitachi or the ITT lasers with regard to the overall beam divergence. The best of the two devices provided to us had a beam divergence of 7.5° at the half-power points and of 12° to 13° at the $1/e^2$ points. The best of the lasers provided by other manufacturers has been found to have a beam divergence of from 16° to 18° at the $1/e^2$ points, and more typically have values in the 25° range.

The RCA laser was butt-coupled into one of our IO SA substrates; however, this assembly could not simultaneously accommodate a detector array because the $LiNbO_3$ had to be tilted in the CERVIT fixture to couple the laser. We later attempted to modify our fixture to correct for this but the laser was destroyed and additional experiments to determine the output spot size with the narrow beam divergence, butt-coupled laser were rendered impossible.

The second RCA laser, which is rotated on its mounting, was used to end-fire couple into the spectrum analyzer. When the laser is properly aligned this experiment yields an output spot-size which is essentially located upon a single 12 μm detector element. The exact size of the input spot as well as the output spot in this experiment has not been measured, but may be determined later in the program in order to simulate the butt-coupled situation and permit measurement of the scattered light intensity on detector elements in the vicinity of the focussed, deflected spot.

3.0 GEODESIC LENS FABRICATION

During this report period we attempted to fabricate some geodesic lenses on a different machine manufactured and operated at the Pneumo-Precision Plant in Keene, New Hampshire. The decision was made to use this machine since it has air bearings for the X and Y drive as well as on the spindle itself. In addition, the technique utilized on this machine involves mapping the tool contour so that different regions of the tool can be utilized in the cutting process. The technique used to date on the Moore Special Tool Company machine involves rotating the tool so that only a single point on the tool is used in cutting. It was felt that these advantages might result in a better surface finish without subsequent polishing. This could be very significant in the fabrication of very short focal length lenses which require cutting very close to the prepolished edge of the substrate. If these lenses require polishing, considerable risk is involved since the polishing tool is likely to slip and contact the polished substrate edge.

The runs made at Pneumo proved inconclusive for several reasons. Firstly, this facility had no means of measuring the surface contour while the piece is still mounted on the machine. When the piece was removed from the machine to be measured, realignment on the machine became a major problem which required extensive jigging to overcome. In addition, the profile map of the tool was non-existent (they simply assume the tool to be spherical) and they had no software for mapping or making contour corrections. Because of these problems, no cutting was performed on the $LiNbO_3$ substrates prepared for this purpose. Numerous runs were made on aluminum blanks, and in general these showed surface finishes which were somewhat better than that obtained with the Moore machine, but not to the point where it justified the large expenditure in both time and funds which would be required to actually machine usable geodesic lenses.

At this point, we had expected to make a lens fabrication run at Moore on a new machine which was to have been available as of the first of April. This machine was to have offered an electronic resolution of 10^{-6} inch and offer in-line direct drive motors in place of the current encoder which utilizes a gearing arrangement. This machine would also feature an interferometer to cross-check the linear motion and to determine lens depth. It would further offer a bigger air bearing with a clutch type connector to replace the felt coupler used on the previous machine. It is this felt coupler which appears to be responsible for much of the spindle type structure which had to be polished out of our earlier lenses. Unfortunately, we were informed by Moore when we called to schedule time on this new machine that it would not be available until August 1. We decided at this point to put off further lens fabrication in order to make use of this new machine during the month of August.

4.0 SYSTEMS ANALYSIS

The first and second bimonthly reports incorporated some of the results of a systems analysis performed to characterize the system performance as a function of various parameters. It was necessary to perform such an analysis as part of this program in order to guide the design of the new spectrum analyzers to be fabricated as part of this program.

The first two reports show the sidelobe pattern on the detector array as a function of the optical beam waist, the corrected portion of the geodesic lens, the deviation of the center of the optical beam from the system axis, the use of a distorted source output and for RF pulses which are shorter than the transit time across the optical beam.

During this report period we looked in greater detail at the short pulse response of the system for pulses ranging from 0.05 μsec up to >2 μsec (the integration time of the detector array). The results indicate that sidelobe performance is severely degraded for any situation in which a sharp edge of a pulse enters or leaves the optical beam during an integration period. Table 1 shows some calculated sidelobe performances on various detector elements for a 1.4 mm optical beam width for CW signals and for various pulses in which both edges of a pulse are seen.

TABLE 1

DIFFERENTIAL DYNAMIC RANGE

NEIGHBORING DETECTOR NO.	1	3	4	5	9
PULSE DURATION					
CW		-72.9	-75.4	-77.6	
1 sec	-13.7	-27.2	-29.5	-31.1	-34.4
0.4 sec	-10.5	-22.6	-24.6	-26.2	-29.1
0.1 sec	- 2	-15.2	-13.5	-18.8	-18.3
0.05 sec	- 0.5	5.1	- 9.8	-14.6	-13.5

We also performed analyses with narrower optical beamwidths and with different transform lens focal lengths in an effort to improve the short pulse performance of the device. The best results on the 2.72 cm focal length lens were obtained with an optical beam width of 0.25 mm. In this case the fourth nearest neighbor dynamic range is of the order of 25 dB. Better results can be obtained by also shortening the focal length of the transform lens, but this would require a smaller center-to-center spacing on the detector array.

5.0 PROGRAM FOR NEXT REPORTING PERIOD

During the next two months of the program we will again not perform any lens fabrication runs, but will wait for the new Moore machine which should become available as of August 1. We will continue to work on the laser butt-coupling problem, and will attempt to solve the problems associated with bonding laser diodes to our heat sinks using unmounted laser diode chips to be provided by Hitachi. We will also work on reducing the detector noise level to enhance the dynamic range by improving the detector sensitivity.

The work performed to date on this program has led to an expenditure of $158K from a total allocation of $205K for the first phase which is to demonstrate a working dynamic range of 40 dB.

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